CHARACTERIZATION OF OZONE EPISODES IN THE SOUTH COAST AIR BASIN: EFFECTS OF AIR PARCEL RESIDENCE TIME AND WEEKEND/WEEKDAY DIFFERENCES

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ABSTRACT

To date, airshed modeling for control strategy evaluations has typically involved simulations of only a few air pollution episodes, which may not represent either the complete range of meteorological conditions over which high ozone episodes can occur, or differences in ozone concentrations resulting from variation in precursor emissions by day-of-the-week. The present project focused on the California South Coast Air Basin (SoCAB) "smog season" of 1 May to 31 October for the years 1986-1993, and had the following primary objectives: to better characterize the range of meteorological conditions associated with high ozone episodes in the SoCAB; to assess the variation in, and influence of, transport and residence time on the occurrence of high concentrations of ozone; to isolate and examine relationships between day-of-the-week and ozone levels; and to examine sub-regional air quality trends over the past decade, including degree of correlation between ozone and NO_2 ambient air concentrations. Fulfillment of these research objectives necessitated the development of comprehensive, critically evaluated air quality and meteorological databases for the SoCAB. In addition to their utility for the present research project, these databases should be of benefit to future air quality research concerning the SoCAB.

Results of this project suggest the need for further investigation of the longstanding view of the importance of air parcel transport across the SoCAB. Specifically, better correlations between NO_2 and ozone concentrations were observed within sub-regions than between them. This finding (while not establishing causality) is consistent with the fact that although the Coastal and Metropolitan subregions were formerly much more densely populated than other regions of the Basin, over the past two decades the major growth in the SoCAB has occurred in the middle and eastern parts of the Basin, producing a commensurate change in emission patterns.

These results are also consistent with those from a comparative analysis of the surface meteorological conditions associated with the days of highest SoCAB peak ozone and days associated with average peak-ozone concentrations. Examination of the vector-mean hourly-average resultant winds throughout the SoCAB for each hour of the day for the high ozone days, along with an analysis of the average time at which the peak ozone value was reported at each station, indicated surface transport on the time scale of a day was of a subregional scale. (However, determination of the actual transport would require wind data aloft which were not available in the present project.) Also of interest was that both average- and highest-ozone days were associated with very similar vector-mean hourly-average resultant winds throughout the SoCAB. Thus, it did not appear differences in transport, at least as far as this was indicated by the surface winds, played a generally significant role in determining the magnitude of the Basin-peak ozone value.

Significant relationships were found, however, between Basin-peak ozone values and both the 850 mb temperature, and the Basin-wide values of maximum surface air temperature. Consistent with earlier studies, temperatures tended to be significantly higher on the high ozone days than on the middle ozone days. Some relationship was also found between the characteristic form of the synoptic-scale weather pattern and corresponding ozone concentrations: specifically, high ozone days tended to occur more often in association with

an "established ridge" aloft (characterized by high mid-tropospheric geopotential heights, a warm lower- and mid-tropospheric air mass, and light winds aloft), while a synoptic-scale pattern with lower heights and stronger and more zonal flow aloft was more typical for middle-ozone days.

Trend analyses were performed by comparing the mean Basin-maximum ozone values of the various CART nodes for 1986-1989 with those for 1990-1993; results indicated that regardless of the meteorological conditions, generally lower peak ozone values were observed in the latter four years than in the first four years.

A further trend analysis was performed by examining the means of the ten-highest hourly-average concentrations for each of the four-year periods. These "worst ozone days" trends showed the most pronounced percentage decrease in these highest ozone concentrations occurred in the western or middle portion of the Basin, corresponding generally to the area of maximum percentage decrease in early morning NO_x ambient concentrations for these same highest ozone days.

Both cumulative hourly ozone exposure above the federal standard of 12 pphm and number of first stage alerts were also found to decrease over the eight-year period of interest for each day of the week for the stations at Central Los Angeles, Azusa, and Riverside (chosen as representative of the western, middle and eastern portions of the urbanized area of the Basin). Higher daily peak ozone concentrations remained more common on weekend days, though, while lower daily maximum concentrations occurred more frequently on weekdays.

Although there was a lack of evidence for NO_2 or NO_x carry-over influencing next-day peak ozone, further investigation of the effect of carry-over of weekday precursor emissions on weekend high ozone episodes is needed. Better correlation of peak ozone with morning NO_2 than with morning NO_x ambient air concentrations was observed.

Implications of all of these results for NO_x and VOC control strategies will remain unclear until more accurate emissions data become available for the SoCAB as a function of day of the week, and by sub-region.

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GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

AFB	Air Force Base
AQMD	Air Quality Management District
AQMP	Air Quality Management Plan
ARB	Air Resources Board
CART	Classification and Regression Tree
DI	Deviation Index
FAA	Federal Aeronautical Association
GEMPAK	General Meteorology Package
GMT	Greenwich Mean Time
IV	Inland Valley
LAX	Los Angeles International Airport
MDL	minimum detectable level
MM5	NCAR Mesoscale Model Version 5
mph	miles per hour
NCAR	National Center for Atmospheric Research
NMC	National Meteorological Center
NMHC	non-methanated hydrocarbon
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
PM-10	particulate matter less than 10 μm in diameter

PDT	Pacific Daylight Time
PST	Pacific Standard Time
ROG	reactive organic gases
SCAQMD	South Coast Air Quality Management District
SCAQS	Southern California Air Quality Study
SGV	San Gabriel Valley
SoCAB	South Coast Air Basin
TPD	ton per day
TSP	total suspended particulate
UAM	Urban Airshed Model
UCLA	University of California, Los Angeles
VOC	volatile organic compound
WD	weekday
WE	weekend